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April 20, 1962

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As per your request, we are enclosing two copies each of specifications and descriptive literature on our [ ] Type 422E Comparator modified STATINTL
STATINTL to mount 250 ft. spools of 9" film, [ ] Type 1045 Data Logger for digitizing the X and Y axis of the Comparator, and the [ ] Type 999 Photoelectric STATINTL Setting Device which aids the operator in setting on some types of images to a greater order of accuracy.

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STATINTL The literature on the [ ] Type 999 Photoelectric Setting Device states that it has been designed to attach to a [ ] Type 422D Comparator, with some changes in the system, it can be attached to a [ ] Type 422E Comparator. STATINTL

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The costs of the above instruments would be as follows:

STATINTL 1. [ ] Type 422E as per specifications dated April 19, 1962

STATINTL 2. [ ] Type 1045 Data Logger as per specifications dated March 1, 1962

STATINTL 3. Adaptation of [ ] Type 1045 Data Logger to the X and Y axis lead screws of [ ] Type 422E Comparator

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STATINTL 4. [ ] Type 999 Photoelectric Setting devices. Price includes adaptation

The above prices are FOB [ ] and do not include STATINTL packaging costs for transportation. This quotation shall be firm for 60 days.

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We shall be most happy to answer any questions you may have in regard to this or any other of our instruments.

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Very truly yours,

[redacted]

CWZ:pc

Enclosure: 422E Specification - April 19, 1962 and Photograph
1045 Specification - March 1, 1962 and Photograph
999 Description - March 1, 1962 and Photograph

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SPECIFICATION

STATINTL TYPE 422E COMPARATOR
(.001 mm Least Count - 250 Ft. Film Stage)

1.0 GENERAL

1.1 Comparator is to provide means for making precise coordinate and angular measurements of images on photographic plates or film.

1.2 Comparator is to consist essentially of a mechanical stage employing precision lead screws and ways giving a longitudinal slide movement of 265 mm and cross slide movement of 250 mm perpendicular to the longitudinal slide, a means for holding plates or film for measurement, a precision rotary table with 360 degrees of motion, a light source, necessary dials and reading optics.

1.3 Design and materials used are to be in accordance with the best engineering practices consistent with precision instrument manufacture.

2.0 SPECIFIC

2.1 The base is to be in a single casting designed for lightness, strength and dimensional stability and have the longitudinal ways in its upper surface.

2.2 The cross slide ways are to be integral with the longitudinal slide and provide cross slide travel at right angles to the longitudinal slide to within plus or minus five seconds of arc.

2.3 The precision lead screw of the longitudinal slide shall have a pitch of one millimeter. The lead screw of the cross slide shall have a pitch of one millimeter.

2.4 The rotary stage shall support the plateholder or film stage horizontally on its upper surface and will be provided with a rapid and a slow motion and shall be free from eccentricity greater than two microns. The opening through the rotary table shall be 9 1/4" x 9 7/8", exclusive of a small amount in the corners. A 1 1/2 in. section in the center of the 9 1/4" width shall be 9 3/4" wide for reading fiducial marks for measurement.

When the film stage is in use, the rotary stage may only be rotated enough to align fiducial marks parallel to the guiding ways.

2.5 The longitudinal lead screw shall have a suitable drive handwheel on its right hand end. The cross screw shall have a similar handwheel on the end toward the operator. Both slides are to be provided with means of rapid disengagement for quick alignment of widely separated points.

2.6 Located at the same end of the precision screws as the drive handwheels, shall be the optical reading dials. By placing the graduations on glass or transparent plastic and providing illumination and magnification, both subintervals and the accumulated turns count shall be seen in the field of view for each screw. Magnifiers and windows for viewing these graduations are to be so positioned as to be read easily and comfortably by the operator. These dials are the means of indicating the longitudinal and cross slide positions directly to .001 mm.

2.7 The film stage shall accommodate 250 foot rolls of 9 inch film. The film transport shall be manual with an electrically released film pressure platen. The clear opening through the film stage shall be 9 1/2" x 9 1/2" but for a short section in the center of the longitudinal direction which is clear up to 9 5/8 inches. Film spool adaptors for 70 mm & 35 mm film are supplied.

2.8 The plateholder shall be capable of supporting plates to 10" x 10" with a clear opening through the plateholder of 9 1/2" x 9 7/8" exclusive of a small amount in the corners. It shall support 8" x 10" plates allowing for a measurable area 8" x 9 7/8".

2.9 The precision circle located on the rotating plate stage shall be graduated in quarter degrees and be read by two verniers 180 degrees apart, to the nearest 20 seconds of arc.

2.10 A condenser type light source shall be provided for the projection system. The light shall be cooled by a blower system to minimize heat effects on the base and precision screws of the instrument.

2.11 The film temperature rise at the plate due to the light source shall not exceed 5 degrees Fahrenheit above the ambient temperature.

2.12 The reading optics shall consist of a two-stage projection system. The image of the point being measured shall be relayed to a reticle plane and the combined image projected to a screen of the front surface type, approximately 5" in diameter, which shall be approximately vertical, supported from the overarm carrying the projection system and at a comfortable viewing range for the seated operator. It shall have a magnification of approximately 15X with a projection system so designed that the view presented on the screen has the same left and right sense as the plate while bottom and top of the projected image have the same sense as front and rear of the plate.

2.13 In addition to the hand cranks for actuating the lead screws, motor drives for rotary motion of the screws shall be provided with a control system to eliminate excessively tedious hand cranking of the screws in moving the carriages from end to end of runs. The motor drives will be provided with safety features to prevent accidental jamming of the nuts at either end of run. The X axis motor drive shall disengage automatically when not being used by the operator. The Y axis motor is a low inertia gear motor and does not need a disengaging system.

2.14 Motors shall turn the screws at a maximum rate of approximately three (3) revolutions per second, this limitation being provided to avoid undesirable heating of the precision screw and nut.

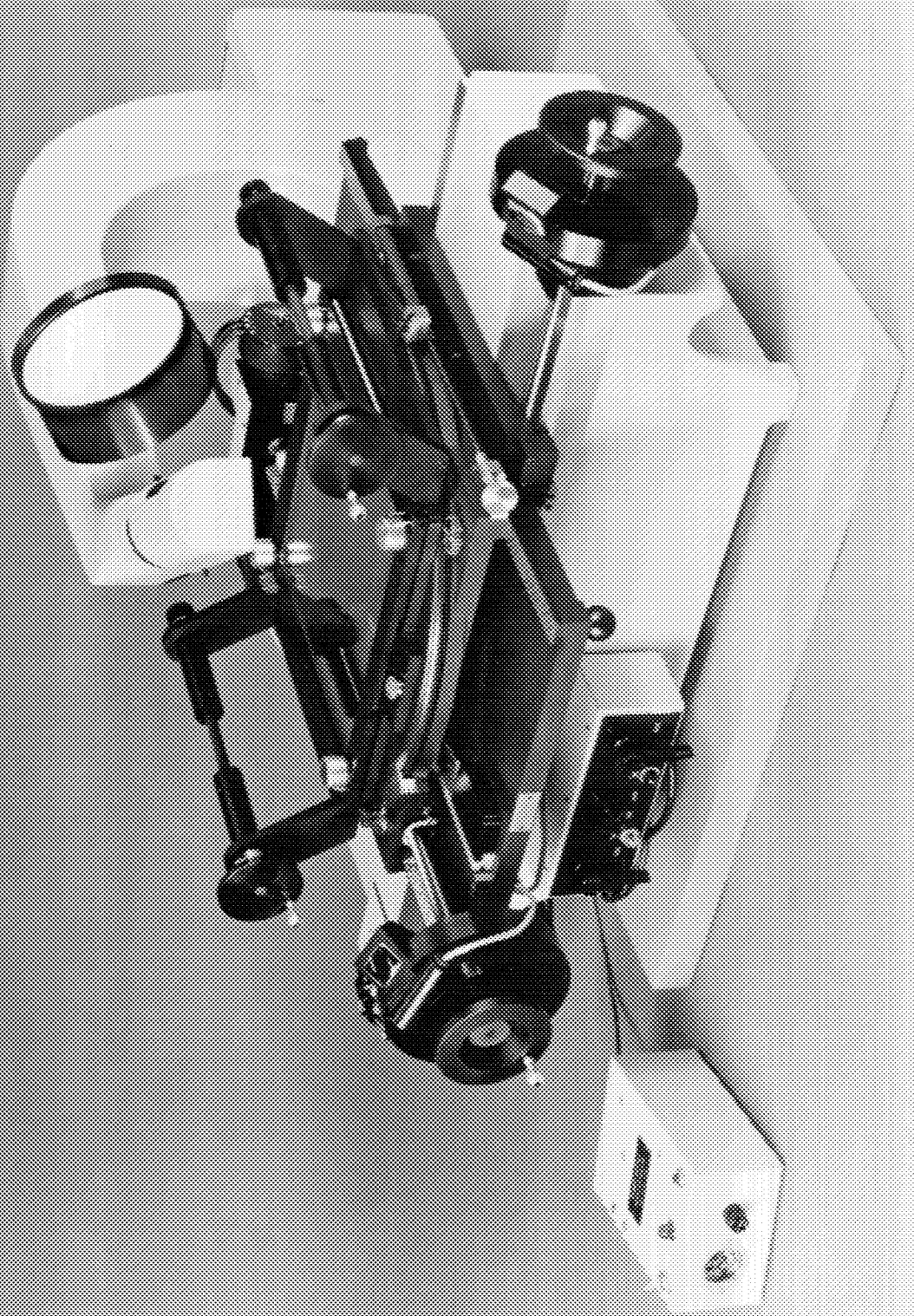
2.15 Accessory box for film stage or plateholder when not being used, oil bottles, lamps, fuses, etc., will be supplied.

3.0 ACCURACY

3.1 Exclusive of the quality of the image being read and human error, the overall accuracy of the instrument is to be as follows:

3.2 The actual stage position at any point in its range of travel shall not deviate from the position indicated by the reading dials by more than .001 mm or .001% of the travel, whichever is greater.

3.3 The rotary table motion is to be accurate to the nearest twenty seconds of arc.



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[redacted] TYPE 422 E COMPARATOR
WITH
200' x 9" FILM STAGE

For options 4 and 5, the circuits shall control tape feeding and punching of twelve different characters in five-level code, the characters corresponding to digits 0 through 9, space, and end. Unless otherwise specified, the output code shall be binary coded decimal with odd parity check as follows:

Character	Code
0	10000
1	00001
2	00010
3	10011
4	00100
5	10101
6	10110
7	00111
8	01000
9	11001
space	11100
end	01110

(NOTE: Almost any code with up to 8 levels can be provided.)

3.4 Output Connections

Any cables, connectors, or couplers required for connecting the data logger to the output device shall be supplied. The data logger shall furnish control power from an internal supply, if required (options 1, 4, 5).

3.5 Printing or Punching Speed

Approximately ten digits per second.

3.6 Circuit Design and Construction

Transistor circuits shall be used. No electron tubes, gas discharge tubes or stepping switches shall be employed. To facilitate servicing, plugin circuit board construction shall be used.

3.7 Power

The data logger shall operate from a power source of 115 volts (nominal), 60 cps, single phase, and shall provide specified performance for line voltages of 90 to 130 volts. Power consumption shall not exceed 100 watts.

3.8 Warmup Time

The data logger shall be ready for use immediately (within two seconds) after power is turned on.

3.9 Interference

Electrical noise and magnetic fields normally encountered in a laboratory, such as those produced when switching motors and fluorescent lamps, shall have no effect on operation of the data logger.

3.10 Size

The electronic unit shall be contained in an attractive cabinet which shall be approximately 19 1/2" wide x 9 1/2" high x 21 1/8" deep.

3.11 Comparator Accuracy

Installation and use of the data logger shall have negligable effect on the accuracy of the comparator. The digitized reading will remain within one bit or count of the comparator dial reading.

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TYPE 422D COMPARATOR

WITH

TYPE 1045 DATA LOGGER

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Approved For Release 2002/06/17 : CIA-RDP78B04747A002100040034-8

March 1, 1962

SPECIFICATION

DATA LOGGER TYPE 1045

STATINTL FOR [redacted] TWO-COORDINATE COMPARATORS

[redacted] STATINTL

1.0 SCOPE

The data logger shall be suitable for connecting to the screws of a measuring comparator, shall digitally encode the X and Y coordinates measured by the comparator and shall display decimal values of these coordinates. The data logger shall also be suitable for connecting to an output writer, card punch, or tape punch, as specified in paragraph 3.3. On readout command, it shall generate electrical signals to cause the output device to tabulate or punch the digital X and Y coordinate values with other data as specified below.

2.0 GENERAL REQUIREMENTS

2.1 Major Components

The data logger system shall consist of two-pulse generator type reading heads, and electronic unit, a footswitch, and an output cable or connector, if required, for coupling to the output device.

2.2 X and Y Inputs

The reading heads shall be arranged for mounting on the measuring comparator and for coupling to the X and Y lead screw drive shafts. The gears, head mounting brackets, shafts and couplings necessary for adaptation are not supplied as part of the data logger. The heads shall furnish electrical signals to the electronic unit for digitally encoding the X and Y coordinates.

2.3 Resolution

The resolution of the encoding process shall be 1,000 counts per turn of the encoder, corresponding to one micron displacement in each coordinate. For comparators with a least count of two or more microns, a change in the electronic unit is needed.

2.4 Range

Each of the X & Y coordinates shall be encoded into a six-decimal digit number, corresponding to a range of up to 1,000 turns of the lead screw or 1,000 mm. range in the corresponding coordinate.

Negative coordinate values shall be indicated as complement numbers. For example, -.001 mm. shall be indicated as 999.999 mm.

2.5 Frame Counter

A six-decimal-digit counter shall be provided, which shall maintain a count of the number of printing or punching cycles that have occurred.

2.6 Identity or Constant Registers

Three registers of six-decimal digits each shall be provided for storing manually-inserted numerical data that is desired to be printed or punched with the coordinate values and frame count.

2.7 Input Keyboard

A keyboard shall be provided on the electronic unit for setting the X and Y registers, frame counter, and identity registers to any desired initial values. Ten keys shall be used for setting in digits 0 - 9. In addition, two keys shall be provided for setting in space and end characters for modifying the output format as specified in paragraph 3.2.

Pushbuttons shall also be provided for selecting the register which is to be set, and these same buttons shall be used for selecting the register whose contents are to be displayed.

2.8 Numerical Display

A six-decimal-digit, in-line, single-plane digital display shall be provided on the electronic unit. This display shall indicate the value of the X or Y coordinate as contained in the corresponding register, the frame count, or the contents of one of the identity registers. Pushbuttons, as specified in paragraph 2.7, shall be provided for selecting the register whose contents are to be displayed.

2.9 Printing or Punching Function

A pushbutton on the electronic unit and a foot switch shall be provided for starting the printing or punching readout cycle. When either of these controls is pressed and released, the digital values of the X and Y coordinates, the frame count, and the contents of the identity registers shall be set automatically into a buffer register, and signals shall be generated to cause printing or punching of the data as set in this register. On each printing or punching cycle, the frame count shall advance automatically one unit.

While the data in the buffer register are being printed or punched, it shall be possible to set the comparator to new coordinates or to set new values into the X, Y, or identity registers or the frame counter. Movement of the lead screws at any time, including the movement when the printing or punching cycle is initiated, shall not cause incorrect readings or other anomalous performance.

3.0 DETAILED REQUIREMENTS

3.1 Input Shaft Speed

0 to 15 revolutions per second in either direction and reversing.

3.2 Output Data Format

The values of X, Y, frame count, and identity digits shall be printed or punched in the following order, with the highest-order digit of each word first:

6 digits of X, space,
6 " " Y, " ,
6 " " frame count, space,
identity digits 1 - 6, space,
" " 7 - 12, " ,
" " 13 - 18, end pulse (carriage return).

If an end character is inserted as a digit in one of the identity registers, an end pulse shall be generated and the printing or punching cycle shall terminate at that point.

3.3 Output Circuits

The output circuits shall provide means for controlling any one of the following devices for printing or punching the desired data as selected at time of purchase.

Option 1: Output writer, IBM model B
Option 2: Summary punch, IBM type 526
Option 3: Card punch, IBM type 024 or 026
Option 4: Tape punch, Friden Model 2
Option 5: Tape punch, Teletype type LARP.

For options 1 - 3, the circuits shall control printing or punching characters 0 through 9, and the space and carriage return (skip for options 2 and 3) functions.

March 1, 1962

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PRELIMINARY DESCRIPTION OF [redacted] TYPE NO. 999 PHOTOELECTRIC SETTING DEVICE FOR PRECISION MEASURING COMPARATOR

STATINTL The [redacted] has been a manufacturer of precision measuring comparators for a period in excess of twenty-five years. These comparators are highly sophisticated measuring microscopes. A photograph on plates or film can be examined and measured with extreme accuracy when mounted on a movable stage which is arranged to traverse one or two coordinates. Travel, along each coordinate, is regulated by precision screws which are arranged to indicate, in microns, the distance each screw travels while readings are being made.

To the present time, however, the operator of a precision measuring comparator has set the image he is measuring on the optical axis of the comparator by a visual method. This can be through the use of a microscope observing system or through the use of a projection system. In making his setting, the operator must mentally determine the photocentric point of the image that he is positioning. Hence, the subjective judgment of the operator becomes a part of the random error associated with the measurements made. With visual setting, for example, the operator must decide where to place the apparent center of a spectrum line or of a diffraction fringe. Perhaps he is trying to set an irregularly shaped stellar image or an image appearing on an aerial photograph. Always, some subjectivity is involved.

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[redacted] developed the Type No. 999 Photoelectric Setting Device principally for the purposes of removing this source of subjectivity of setting. With the Photoelectric Setting Device, the subjective judgment of the

operator is reduced by a very large factor. It has been demonstrated repeatedly that the precision of setting is greatly improved for any given operator and further, with photoelectric setting, different operators will agree in their settings extremely closely. Another advantage of photoelectric setting is the reduction of operator fatigue and eyestrain from continued use of a comparator requiring visual setting.

Photoelectric setting has been reported several times in the scientific literature. Three important references are as follows: F. S. Thompkins and M. Fred,"Photoelectric Setting Device for a Spectrum Plate Comparator," J.O.S.A. 41, 641 (1951); J.M. Bennett and W. F. Koehler, "Comparator with Photoelectric Detection for Setting on Broad Interference Fringes with Precision," J.O.S. A. 49, 466 (1959); D. W. Steinhaus, "Photoelectric Comparator for Wavelength and Intensity Measurements of Spectra," J. O. S. A. 49, 468 (1959).

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The above quoted articles, however, were limited to photoelectric setting in one coordinate. The [redacted] has now expanded the application from one coordinate to two coordinates and patent applications have been initiated to cover the two-coordinate device. The present instrument may be supplied either as a single or two-coordinate device, and it has been found to be exceedingly useful for positioning trepanned holes in two coordinates and for work in one coordinate on spectrum lines, diffraction fringes, and ruled scales. The two-coordinate device has also been used on stellar images and on finding the center position between chopped ballistic trails. With the Photoelectric Setting Device, it is possible to achieve standard deviations of the order of magnitude of less than one-half micron. This can be less if the material being measured is of high contrast and good quality.

The currently available device has been designed so that it may be

STATINTL attached to the Type 422D [redacted] Comparator. This two-coordinate comparator can accommodate plates and films to 10 in. x 10 in. with a measurable area to

9 in. x 9 in. in a range of 265 mm in the X coordinate and 250 mm in the Y coordinate. Other adaptations of the Photoelectric Setting Device are now in development for use on other STATINTL Precision Measuring Comparators.

A brief description of the operation of the Photoelectric Setting Device for the Type 422D Comparator is now given. A dichroic-type beam splitter is used so that visual observation on a viewing screen at 22X magnification may also be coupled with photoelectric setting. A smaller portion of the light (not used for the viewing screen) is brought to a secondary focal point in the attachment device. This secondary image is then focused upon a stationary reticle at a 10X magnification. Between the projection lens and the reticle is a rotating glass cube which causes the image of what is being positioned to be swept across the reticle. The rotating cube has two opposite faces that are blackened. A photomultiplier tube is located behind the reticle and the output of this tube is fed to the vertical plates of an oscilloscope. The horizontal sweep is so arranged that, if the image being positioned is off the optical axis, mirror image pips will appear on the oscilloscope. Movement of the comparator motions will bring these mirror image pips into coincidence. When this occurs, exact positioning has been achieved. It should be pointed out that the human eye and brain is very sensitive to the detection of a symmetrical situation. Although the horizontal distance on the oscilloscope is not great for one micron of comparator motion, it is still possible to make submicron precision settings due to this ability of the eye to bring symmetrical images into coincidence.

In the making of measurements to a precision better than one micron, it is obvious that phase shifts in the electronic circuit cannot be tolerated. It is, for example, absolutely essential that the horizontal sweep generation for the oscilloscope be exactly in phase with the rotating cube. This has been accomplished in STATINTL the device by an optical system of generating the horizontal sweep voltage. A spinning chopper of proper shape is physically attached to the shaft of the motor which also bears the scanning cube. A small light illuminating a silicon cell

through the spinning chopper then gives a signal for the generation of the horizontal sweep. The chopper has been designed so that a very linear, triangular shape horizontal sweep is achieved. Because of the rigid connection of these two elements, cube and chopper, it is absolutely impossible for these two important devices to get out of phase. This is in contradistinction to methods that have been previously used which use the line voltage for generating the horizontal sweep, depending upon the synchronous motor to stay in phase with the line voltage. Synchronism in such a system is not sufficiently constant for submicron setting precision.

In the two-coordinate device, use of Polaroid has enabled the separation of the X and Y settings, so that the X coordinate and Y coordinate are positioned in sequence without the disturbing display of extra pips on the oscilloscope.

It is, of course, desirable that the visual on-axis position coincide exactly with the photoelectric on-axis position. This permits visual settings where necessary and parallel plates have been installed in the attachment with readily available fine adjustment at the front of the attachment which permit easy bringing into exact coincidence the photoelectric and visual centers.

The present Photoelectric Setting Device is useful for many of the types of images that are now important to a variety of scientific laboratories. It is STATINTL altogether possible, by reticle redesign, to make the instrument more versatile and applicable to specialized cases. The [redacted] will be very pleased to consider specialized situations and to advise on the feasibility of photoelectric setting for any special applications brought to their attention.

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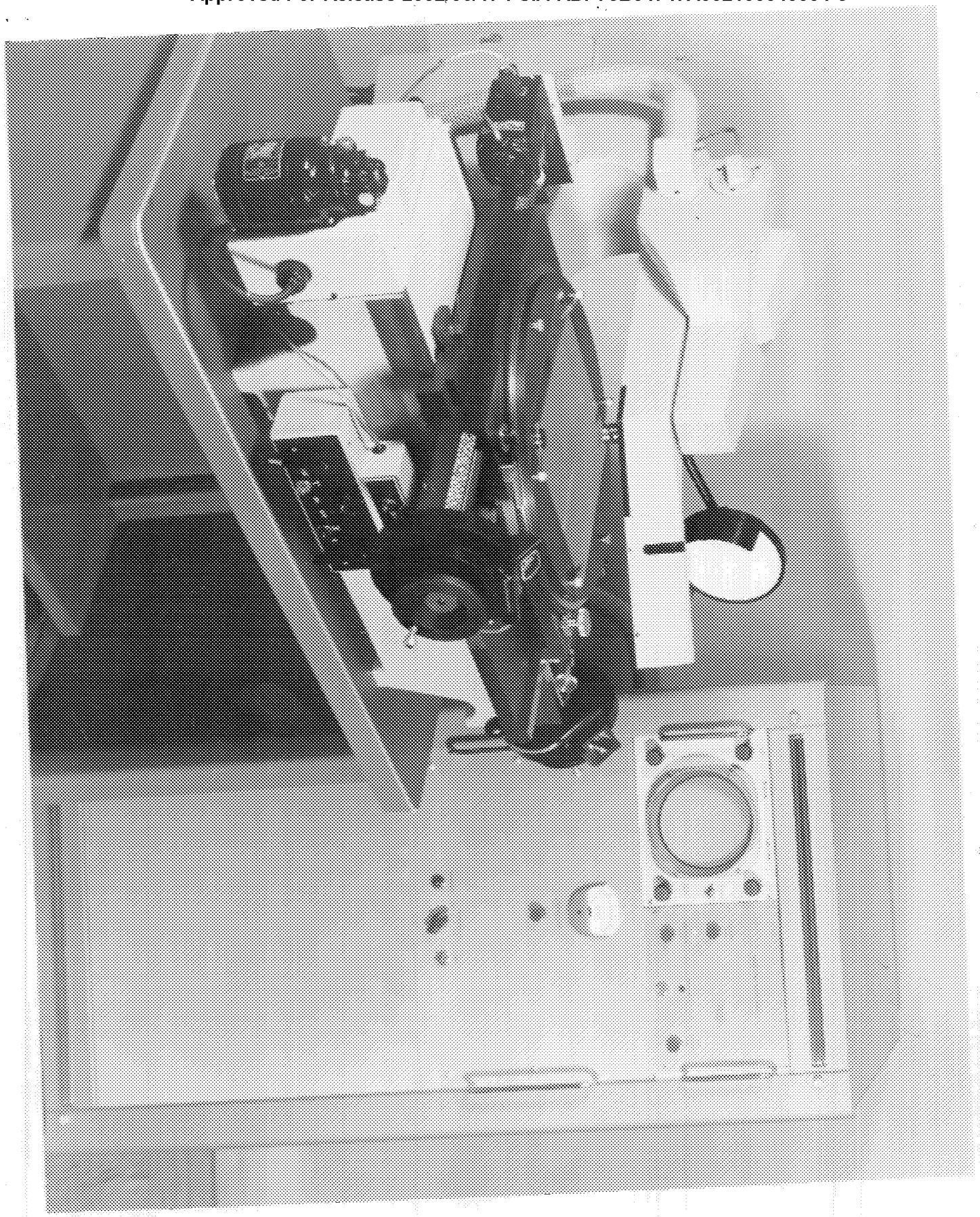

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TYPE 422 D COMPARATOR

WITH

TYPE 999 PHOTOELECTRIC

SETTING DEVICE.

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TYPE 586 LENS TESTING BENCH SPECIFICATIONS Dated: December 1958

I. SCOPE

1.1 This specification covers fabrication of one particular type of versatile and precision lens testing bench.

II. REQUIREMENTS

2.1 DESIGN:

This lens testing bench shall be a versatile and precision lens testing bench and its construction of such accuracy that all measured defects of imagery are due solely to the objective lens under test. It shall be of the nodal slide type and provided with flat field bars. It shall accomodate lenses of all focal lengths up to 1220 mm and diameters from .5 inch to 7 inches. It shall include provisions for centering and revolving the lens under test, and the microscope shall be capable of being moved in three mutually perpendicular planes through calibrated micrometer screws. The microscope shall be capable of rotation about its object point through an angle of 100 degrees and also permit testing of telephoto lenses and lenses having extreme distortion.

2.2 MATERIALS AND CONSTRUCTION (General):

The lens testing bench shall include but is not limited to the following major parts:

2.2.1 Carriage lens holder, complete with nodal slide and adjustments (Parts 1-10).
2.2.2 Carriage inspection, complete with microscope and adjustments (Parts 12-19).
2.2.3 Bench base and support (Parts 20-31).
2.2.4 Camera Attachment.

2.3 MATERIALS AND CONSTRUCTION (Detail):

2.3.1 On the front end shall be a bearing whose axis is vertical and on which the nodal slide (1) and independent focal length slide assemblies (2) rotate. The mechanism for holding the lens (5-10) shall be attached to the nodal slide which permits placing the nodal point of the lens over the axis of rotation.
2.3.2 While manufacturing this bench, modern ball bearings shall be used to insure free movement of parts in the desired direction only and to eliminate lost motion. Wherever possible, light weight alloys shall be used to reduce loading on ball bearings.
2.3.3 In order that the measurement of focal length, variation from a flat field and distortion may be made to the accuracy desired, the errors

in construction, and of the measuring means, shall be kept to less than .01 mm.

2.3.4 The bed shall be supported on two columns (23), in such a manner that the front end rests on a ball and socket joint, and the rear end rests on two leveling screws. Also at this point shall be a pair of opposing screws (30), which permit rotation of the bed in a horizontal plane through an angle of 1 degree so that precise alignment can be obtained when employing a collimator. This requires that the ball and socket joint is placed in line with the axis of rotation of the nodal slide in order to make possible this adjustment about the nodal point of the lens.

2.3.5 The bed itself shall be of cast iron fully normalized before the final planning. The ways of the bed shall be the V and flat type, hand scraped to insure straightness and freedom from twist.

2.3.6 The front end of the bed shall be machined to receive the nodal assembly in such a manner that its axis is perpendicular to the longitudinal plane of the ways of the bed.

2.3.7 The nodal slide assembly shall be mounted directly on a heavy steel spindle, which turns on a preloaded ball bearing. It shall be provided at its upper end with a circle (22) and vernier reading to minutes, and its lower end with a worm wheel. The worm for driving this worm wheel shall carry a splined shaft extension (24), which has to be housed in a channel lengthwise in the side of the bed.

2.3.8 The hand wheel assembly (25) for driving the spline shaft shall be constructed such that it can be clamped at any point along the bed within easy reach of the operator.

2.3.9 For rigid construction and to attain free movement with no lost motion, the nodal slide and focal length slide shall be of hardened steel and ball bearing construction. They shall be actuated by rack and pinion drives (3 and 4), with coarse and fine motion.

2.3.10 The nodal slide travel shall be so proportioned as to permit the examination of any telephoto lens whose nodal point lies within 100 mm in front of the lens mount.

2.3.11 Carried on a bridge (5) over the nodal slide shall be an independent centering slide (6), upon which the lens holding mechanism shall be mounted. It shall consist of a hardened and ground ring (9) whose curved outer edge fits into the concaved grooves which shall be ground into the outer races of three ball bearings (8). The positions of the two lower rollers shall be fixed, and the top roller should be provided with an adjustment (7) for setting the axis of rotation of the ring parallel to the horizontal plane of motion of the microscope carriage along the bed. This rotatable ring shall be provided with a graduated circle reading to a half degree. This will be very helpful in optically centering lenses and rapidly examining various sectors in the field of an objective. For use with this lens ring shall be a number of interchangeable sets of radially adjustable lens holding jaws (10). The assembly shall be sturdy enough to hold any lens up to 3 1/2 inches in diameter and weighing approximately five pounds. For holding larger lenses, there shall be available a second ring having tapped holes to which lens mounts may be secured.

2.3.12 The bench shall employ the flat field bar principle for the connection of the focal length slide with the microscope carriage. Part (11) and (14) in the attached drawing indicate the arrangement of the bar, connecting the lens holder with the microscope carriage. Three flat field bars of 60, 100 and 160 cm in length shall be supplied to conveniently cover the range of focal length accomodated by the bench. One bar would cover all cases except those lenses of very short focal lengths. However, the selection of a suitable bar shall make it possible to have the collimator placed nearer the bench than normally used. These bars shall provide automatically a flat field for the observing microscope to follow upon rotation of the nodal slide. The microscope carriage shall contact the bed at 3 points by means of ball bearings used as rollers.

2.3.13 A projection (13) in front of the microscope carriage shall carry a ball bearing roller (12) contacting the side of a steel rod inlet into the face of the flat field bar (14).

2.3.14 At zero focal length, the axis of this roller shall be in exact coincidence with the axis about which the nodal slide rotates. This coincidence shall be effected by adjusting the microscope carriage rollers through eccentric bushings provided for this purpose. Constant contact shall be maintained between the face of the flat field bar and its ball bearing follower through the use of a counter weight (31) which shall be suspended from one end of the bench by a pulley system and attached to the carriage by a flexible cord (20). This flexible cord shall be a twin conductor, rubber covered cable which also shall serve as a lead for supplying electrical power to a small lamp. This lamp shall be the illuminator for a scale reading microscope (27) mounted to the side of the microscope carriage. It shall be used to read the precision focal length scale (28) mounted on the side of the bed. The bench shall be equipped with two focal length scales, one of which shall be a coarse scale, (29) graduated in millimeters and numbered every tenth millimeter. It shall be read from an engraved line index on the microscope carriage to the nearest millimeter. The precision scale shall be diamond ruled with graduations every millimeter. It shall be read to one-hundredth of a millimeter in conjunction with a reticle in the scale reading microscope to permit measurements to be made as specified in section 2.3.3.

2.3.15 At the top of the microscope carriage shall be a plate (13) pivoted over the axis of the flat field bar follower. Mounted on this plate shall be ball bearing slides moving in three mutually perpendicular planes. The observing microscope carried by these slides shall be focussed on a point coincident with the axis of rotation of the plate and the flat field bar follower. The motion of the microscope about this axis in a horizontal plane shall be possible through a total angle of 100 degrees and shall be read directly on a sector of a circle graduated in half degrees.

The microscope ways shall be actuated by micrometer screws (17, 18, 19) graduated to read in hundredths of a millimeter, with sufficient motion to measure the most severe cases of curvature of field and distortion likely to be encountered; the precision of graduations of the micrometer screws shall not limit the overall precision of the bench. The microscope shall be equipped with three eyepieces of four, six and ten times magnification and a filar eye-piece (16) of standard design. Four parfocalized objecti v es (15) whose effective focal lengths shall be 32, 16, 10 and 4 millimeters in a quadruple nose piece shall provide a range of magnification suitable for all purposes. All eye-pieces shall be equipped with crosshairs and all optical elements shall be provided with reflection reducing coatings. The ocular shall be inclined to the tube for convenience in viewing the image under inspection.

2.3.16 A 35mm camera shall be attached to a tube which would replace the microscope. The tube shall be wide enough to hold a microscope lens inside on an axially adjustable tube.

III. MATERIAL AND MECHANICAL REQUIREMENTS

3.1 The design and fabrication of all optical and mechanical elements shall be of highest quality workmenship and consistent with the most recent optical and related principles available and shall incorporate such characteristics and quality as required for lens testing bench tests of very high accuracy and high precision of measurement.

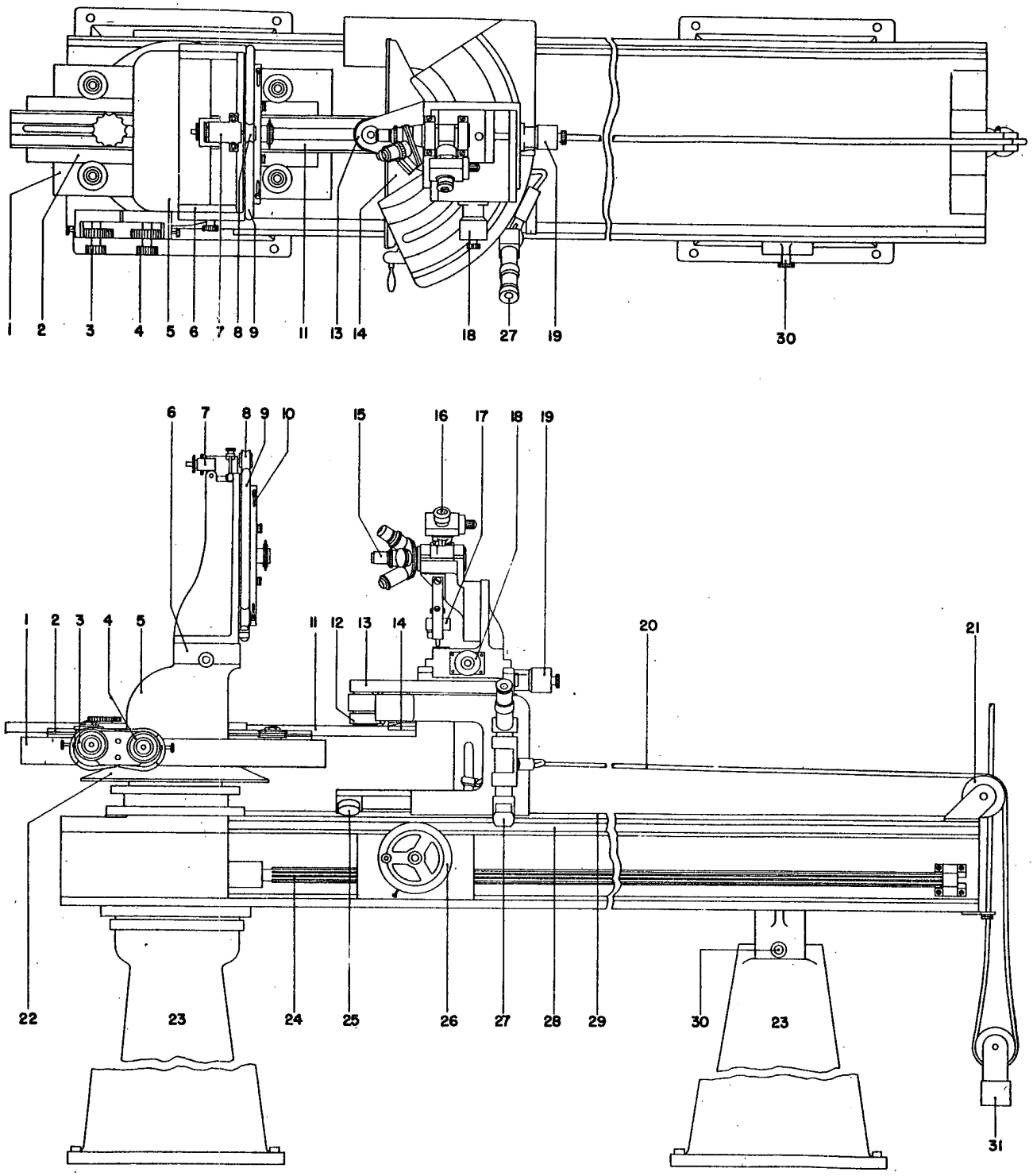


Figure 1

Plan and Elevation Views of Lens Testing Bench

LEGEND FOR FIGURE 1

1. Nodal Slide
2. Focal Length Slide Assembly
3. Drive for focal length slide ($\frac{\text{fast}}{\text{slow}} = \frac{4}{1}$)
4. Drive for nodal slide ($\frac{\text{fast}}{\text{slow}} = \frac{4}{1}$)
5. Bridge
6. Centering slide and screw (carries lens board)
7. Adjustment for upper bearing of lens board
8. Ball bearing support for lens board
9. Lens Board (1/2° divisions)
10. Lens holding jaws (Scroll adjustment)
11. Blade of flat field bar
12. Flat field bar guide roller
13. Plate, supports microscope assembly & pivots about axis of guide roller.
14. Head of flat field bar
15. Microscope Objectives
16. Microscope Eyepieces
    Filar micrometer and other eyepieces interchangeable
17. Micrometer screw (.01 mm) X-coordinate, 12 mm of travel
18. Micrometer screw (.01 mm) X-coordinate, 25 mm of travel
19. Micrometer screw (.01 mm) Y-coordinate, 30 mm of travel
20. Power cord for microscope illumination, also tension cord for microscope carriage.
21. Pulley for tension cord

LEGEND FOR FIGURE 1 (cont.)

22. Circle & vernier, rotation about nodal axis (reading to minutes).

23. Pedestals

24. Splined shaft (rotates nodal spindle)

25. Microscope carriage support rollers

26. Handwheel for rotating nodal slide

27. Microscope for reading focal length scale

28. Precision focal length scale

29. Coarse focal length scale

30. Opposing screw for aligning bed parallel to collimator axis.

31. Weight & pulley for tension on cord

STATINTL

[redacted]

586 LENS BENCH

May 19, 1961

[redacted] TYPE 935 PRECISION LENS TESTING BENCH SPECIFICATIONS

FINAL SPECIFICATIONS

I SCOPE

1.1 This specification covers design and fabrication of a lens testing bench, providing for the measurement of focal lengths up to 70 inches to an accuracy of ±.0005 inches. This lens testing bench will also measure back focal distance, distortion, curvature of field, and other aberrations.

II REQUIREMENTS

2.1 This lens testing bench shall be precise and its construction shall be of such accuracy that all measured defects of imagery will be due solely to the objective lens under test. The bench shall be of the nodal slide type and be provided with a flat field bar. The bench shall accommodate lenses up to 70 inch focal lengths, lens cell diameter of 18 1/2 inches including flange and lens cell weight of 350 pounds. The barrel of the lens shall not exceed 14 5/8 inches.

The bench shall be made specifically to mount a lens cell of no greater than 18 1/2 inches diameter and about 20 inches in length. The bench shall include provisions for a centering slide to bring the lens axis over the axis of rotation of the nodal slide. The lens cell may be rotated a full 360 degrees about its own optical axis.

The microscope on the inspection carriage shall be capable of being moved in three mutually perpendicular planes by means of precision micrometer screws. The microscope shall be capable of rotation about its object point through an angle of plus and minus 20 degrees.

2.2 Materials and Construction (General)

2.2.1 Carriage, lens cell holder, complete with nodal slide, flat field bar slide, centering slide, and adjustments.

2.2.2 Carriage, inspection, complete with microscope, adjusting slides and provision for mounting accessories.

2.2.3 Bench base, and supports.

2.3 Materials and Construction (Detail)

2.3.1 On the front end shall be a bearing whose axis is vertical and on which the nodal slide and independent focal length slide assemblies rotate. The carriage for holding the lens cell shall be attached to the nodal slide which permits placing the nodal point of the lens over the axis of rotation. The nodal slide shall have 6 inches of fine motion divided plus or minus 3 inches from the vertical axis of rotation. The flat field bar adjusting slide shall have 6 inches of fine adjusting motion after which the flat field bar clamp may be loosened and the flat field bar slid to a new rough position.

2.3.2 While manufacturing the bench, modern precision antifriction bearings shall be used to insure free movement of parts in the desired direction only and to eliminate lost motion. Light-weight alloys are permissible to give better center of gravity locations and reduce loading, provided the temperature effects do not degrade accuracy of measurement over the range of room temperatures 72°±0.5°.

Construction of the bench shall be such that it will not be affected by a relative humidity of 30% to 45%.

2.3.3 In order that the measurement of focal length may be made to the accuracy desired the total accumulated errors in construction and of the measuring means shall be no greater than .01mm.

2.3.4 The bed shall rest on two Meehanite cast iron plates ribbed for strength and stress relieved for stability, which shall be mounted on the top of two concrete piers furnished by the customer, to drawings furnished by [redacted] By moving these STATINTL plates to new piers and going through the installation procedure again, it will be possible to move the bench to a new location.

Alignment of optical axis of testing bench and collimator shall be accomplished by movement of the collimator. The bed of the bench shall be supported by the piers in a manner free of distortion.

2.3.5 The bed itself shall be of the Meehanite type of cast iron fully normalized before the final planing. The ways of the bed shall be hand scraped and lapped to insure that final straightness and twist errors do not exceed .0003 inch.

2.3.6 The front end of the bed shall be so attached to the nodal assembly base that the nodal assembly axis of rotation is perpendicular to the longitudinal motion of the microscope carriage within one minute of arc.

2.3.7 The nodal slide assembly shall be mounted directly on a heavy steel spindle which rotates in a precise bearing assembly. Over the ±10° rotation of the nodal assembly about the zero position, the axial shift of the spindle in any horizontal direction shall be less than .0001 inch TIR, measured at the intersection of the vertical nodal axis and the optical axis of the lens under test. A circle sector and vernier

shall be mounted so rotation may be read to one minute by means of the vernier. Accuracy shall be one minute. The nodal assembly shall permit free rotation such that it may be oscillated for nodal point location by using the flat field bar as a lever arm. Clamping shall be by clamping the flat field bar near the microscope carriage. A tangent motion shall be provided such that fine rotational motion of the nodal slide assembly may be made from the front end of the bench. The tangent motion will be provided with a safety friction device so that no damage can result if used while the flat field bar is locked.

2.3.8 For rigid construction and to attain free movement with no lost motion the nodal slide and focal length slide shall be of hardened steel and ball bearing construction. These slides shall be actuated by fine motion drives driven by selsyns. The transmitters shall be located convenient to the operator's hand when he is at the microscope carriage. They will be movable along the bed of the bench.

2.3.9 Carried on the upper surface of the nodal slide assembly shall be an independent centering slide upon which the lens cell holding mechanism shall be mounted. This slide shall permit a transverse movement of one inch in the plane perpendicular to the axis of the nodal spindle with a slave screw for positioning and a dial gage for monitoring the position of the slide.

2.3.10 The carriage or cradle that mounts the cell adapter shall be fastened at the top of the centering slide. The cell adapter shall be supported on a pair of rollers on each end and positioned endwise by a guiding

shoe against the end of the cell adapter. Full 360° rotation of the cell about its own optical axis will be allowed. Rotation of the cell shall be monitored by a circle graduated in half-degree increments applied to the cell adapter. Provision shall be made to allow ±2mm of motion of the supporting rollers on one end to compensate for tilt that might be introduced by the variations in the diameters of the cell adapter. The motion shall be in the nature of a semi-permanent type of adjustment rather than a routine adjusting or measuring motion. The motion to compensate for tilt shall be monitored by a dial gage readout in hundredths of a millimeter.

2.3.11 The bench shall employ the flat field bar principle for the correction of the focal length slide with the microscope carriage. One bar shall provide for lenses 48 to 70 inches focal length with an offset head of 9 inches toward the operator and 13 inches to the rear. The head shall be perpendicular to the flat field bar slide and nodal slide and its guiding face flat so that errors in measuring focal length and distortion due to the flat field bar head alone shall be commensurate with the overall accuracy of the system. This bar shall automatically provide a flat field for the observing microscope to follow upon rotation of the nodal slide. To make focal length and back focal length determinations easier, a separate bar for this purpose only shall be furnished. Similarly, during initial adjustment of the bench when the microscope must observe zero focal length or, for example, a reticle on an extension of the nodal spindle axis, the special length bar above shall be used.

2.3.12 A projection in front of the microscope carriage shall carry a precision ball-bearing roller contacting the side of the head of the flat field or T-bar.

2.3.13 At zero focal length the axis of this roller shall be in coincidence with the axis about which the nodal slide rotates. Constant contact shall be maintained between the face of the flat field bar and its ball bearing follower through the use of roller and spring preloading device. A low voltage source in the microscope carriage will be furnished to power the scale reading system lamp. This lamp shall be the illuminator for a scale reading microscope mounted to the side of the microscope carriage. The microscope shall be used to read the precision focal length scale mounted on the side of the bed. The bench shall be equipped with two focal length scales, one of which shall be a coarse scale graduated in millimeters and numbered every tenth millimeter. The coarse scale shall be read from an engraved line index on the microscope carriage to the nearest millimeter. The precision scale shall be diamond ruled with graduations every millimeter. It shall be read to one-hundredth of a millimeter in conjunction with a reticle in the scale reading microscope to permit measurements to be made as specified in Section 2.3.3.

2.3.14 At the top of the microscope carriage shall be a plate pivoted over the axis of the flat field bar follower. Mounted on this plate shall be ball bearing slides moving in three mutually perpendicular planes. The observing microscope carried by these slides shall be focused on a point coincident with the axis of rotation of the plate and the flat field bar follower. The motion of the microscope about this axis in a horizontal plane shall be possible through a total angle of 40° and

shall be read directly on a sector of a circle graduated in half degrees. The microscope ways shall be actuated by micrometer screws graduated to read in hundredths of a millimeter. The 25mm range of motion is sufficient to measure the most severe cases of curvature of field and distortion likely to be encountered during the test. The precision of the micrometer screws shall not limit the overall precision of the bench. The microscope shall be equipped with three eyepieces of four, six and ten times magnification and a filar eyepiece of standard design. Four parfocalized objectives whose magnifications shall be 5X, 10X, 20X and 40X will be mounted in a quadruple nose-piece and provide a range of magnification suitable for all test purposes. All eyepiece optical elements shall be provided with reflection reducing coatings. The ocular shall be inclined to the microscope tube for convenience in viewing the image under inspection, and shall be adjustable for focussing on the fixed crosshair which is an integral part of the microscope assembly.

2.3.15 Provision will be made so that microscope assembly may be removed easily and other accessories, such as the target projector, and camera attachment may be mounted and used.

III ACCESSORIES

3.1 A Target Projector for projecting a target through the microscope optical system into the focal plane of the microscope which may be picked up by the lens under test and returned to the focal plane of the microscope by autocollimation techniques where it is observed in the usual manner by the normal microscope system. The usual prism in the microscope is replaced by a beam splitter and at a distance equal

to the path length between objective plane and microscope reticle, provision is made for mounting a small target to be furnished by the customer. Illumination is of the low voltage incandescent type.

2.3 A Camera Attachment to be substituted for the microscope for recording what the bench operator or observer would see through the microscope. The camera attachment consists of a cylindrical mount which fits the same mounting points as the microscope with a stop which permits the emulsion to be placed in the same plane as the focal plane of the microscope. A film transport device on the end of the cylindrical mount accepts either 20 or 36 exposure cassette of 35mm film to permit daylight loading. It has an automatic stop feature on the film wind that permits either 20 or 36 exposures depending upon the load in the cassette. The film is flattened on a vacuum platen during exposure. Area of exposure is 1/4" in diameter. To keep vibration to a minimum, exposure is permitted by opening a shutter manually and triggering an electronic flash which is part of the collimator and not part of the optical bench. These accessories must be ordered at the same time as the bench.

IV. MATERIAL AND MECHANICAL REQUIREMENTS

4.1 The design and fabrication of all optical and mechanical elements shall be of highest quality workmanship consistent with the most recent optical and related principles available, and shall incorporate such characteristics and quality as required for lens testing bench tests of very high accuracy and high precision of measurement. Because of the nature of the environment in which this bench is used and the need for unusual accuracy MIL Specs do not apply.

935 LENS BENCH

February 15, 1962

STATINTL SPECIFICATIONS FOR [ ] TYPE 890 PRECISION LENS TESTING BENCH

NOTE: - These specifications supersede all previous specifications and correspondence as regards this model.

I SCOPE

1.1 This specification covers fabrication of one particular type of versatile and precise lens testing bench.

II REQUIREMENTS

2.1 DESIGN:

This lens testing bench shall be a versatile and precise lens testing bench to facilitate the quick and accurate determination of the defects of imagery of the objective lens under test. It shall be of the nodal slide type with flat field bars. It shall accommodate lenses of 3/4" to 6" diameter whose weight including cell does not exceed five pounds. The microscope system observing the image point of the lens under test shall be capable of being moved in three mutually perpendicular planes by means of slides actuated by precision micrometer screws. Focal lengths up to 1220 mm shall be accommodated.

2.2 MATERIALS AND CONSTRUCTION (General):

The lens testing bench shall include, but is not limited to, the following major parts:

2.2.1 Carriage lens holder, complete with nodal slide and adjustments.

2.2.2 Carriage inspection, complete with microscope and adjustments.

2.2.3 Bench base and support.

2.3 MATERIALS AND CONSTRUCTION (Detail):

2.3.1 On the front end shall be a bearing whose axis is vertical and on which the nodal slide and independent focal length slide assemblies rotate. The mechanism for holding the lens under test shall be attached to the nodal slide which permits placing the nodal point of the lens over the axis of rotation.

2.3.2 While manufacturing the bench, modern ball bearings shall be used to insure free movement of parts in the desired direction only and to eliminate lost motion. Wherever possible, light weight alloys shall be used to reduce load on ball bearings.

2.3.3 In order that the measurement of focal length, variation from a flat field and distortion may be made to the accuracy desired, the errors in the construction and the measuring means shall be kept to less than .025 mm, except that of the focal length scale which shall be .05 mm.

2.3.4 The bed shall be supported on two columns, in such a manner that the front end rests on a ball and socket joint and the rear end rests on two leveling screws. At the rear end shall be a pair of opposing screws which permit rotation of the bed in a horizontal plane through an angle of 1^{o} so that precise alignment can be obtained when employing a collimator. This requires that the ball and socket joint is placed in line with the axis of rotation of the nodal slide in order to make possible this adjustment about the nodal point of the lens.

2.3.5 The bed itself shall be of Meehanite fully normalized before the final planing. The ways of the bed shall be of the kinematic type, hand scraped and lapped to insure straightness and freedom from twist.

2.3.6 The front end of the bed shall be machined to receive the nodal assembly in such a manner that its axis is perpendicular to the longitudinal plane of the ways of the bed.

2.3.7 The nodal slide assembly shall be mounted directly on a heavy steel spindle, which turns on a preloaded ball bearing. It shall be provided at its upper end with a circle and vernier reading to one minute, and its lower end with a wormwheel. The worm for driving this wormwheel shall carry a shaft extension which has to be housed in a channel lengthwise in the side of the bed.

2.3.8 The handwheel assembly for driving the worm shaft shall be constructed such that it can be used at two points along the bed within easy reach of the operator.

2.3.9 For rigid construction and to attain free movement with no lost motion, the nodal slide shall be of hardened steel and ball bearing construction. The focal length slide shall be of steel with specially shaped ball bearing roller units as mounts and guides. They shall be actuated by rack and pinion drives with coarse and fine motion.

2.3.10 The nodal slide travel shall be $\pm$ 3 inches about a point slightly in front of the lens mount.

2.3.11 Carried on a bridge over the nodal slide shall be an independent centering slide, upon which the lens holding mechanism shall be mounted. The lens holding mechanism shall be a pair of opposing V's moved by left and right hand screws for lenses from 3/4" to 6" diameter and weighing not over five pounds. For other lenses, the lens holding assembly may be removed and lens adapters added to the top of the centering slide.

2.3.12 The bench shall employ the flat field bar principle for the connection of the focal length slide with the microscope carriage. Two flat field bars of 60 and 160 cm in length shall be supplied to conveniently cover the range of focal lengths accommodated by the bench. One bar would cover all cases except those lenses of very short focal lengths. However, the selection of a suitable bar shall make it possible to have the collimator placed nearer the bench. These bars shall provide automatically a flat field for the

observing microscope to follow upon rotation of the nodal slide. The microscope carriage shall contact the bed at four points by means of ball bearings used as rollers.

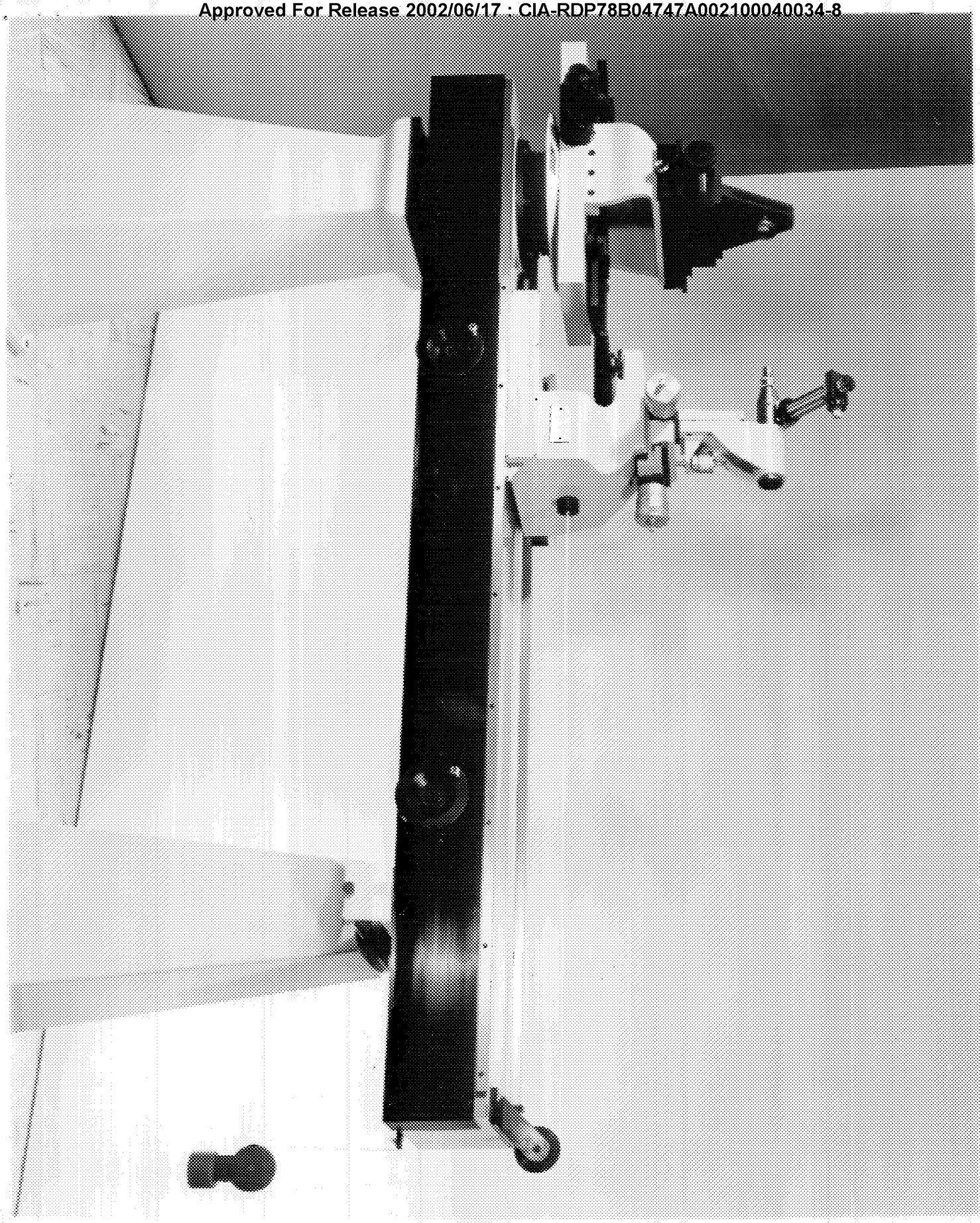
2.3.13 A projection in front of the microscope carriage shall carry a ball bearing roller contacting the side of the flat field bar.

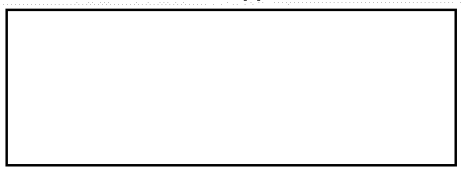
2.3.14 At zero focal length, the axis of this roller shall be in coincidence with the axis about which the nodal slide rotates. Constant contact shall be maintained between the face of the flat field bar and its ball bearing follower through the use of a counter weight which shall be suspended from one end of the bench by a pulley system and attached to the carriage by a flexible cord. The bench shall be equipped with a focal length scale, which shall be graduated in millimeters and numbered every tenth millimeter. It shall be read from an engraved vernier carried by the microscope carriage to the nearest .05 millimeter.

2.3.15 At the top of the microscope carriage shall be ball bearing slides moving in three mutually perpendicular planes. The observing microscope carried by these slides shall be focused on a point coincident with the axis of rotation of the flat field bar follower. The microscope ways shall be actuated by micrometer screws graduated to read in hundredths of a millimeter, with sufficient motion to measure the most severe cases of curvature of field and distortion likely to be encountered. The objective whose effective focal length shall be 16 millimeters in a standard nosepiece shall be furnished. The ocular shall be inclined to the tube for convenience in viewing the image under inspection.

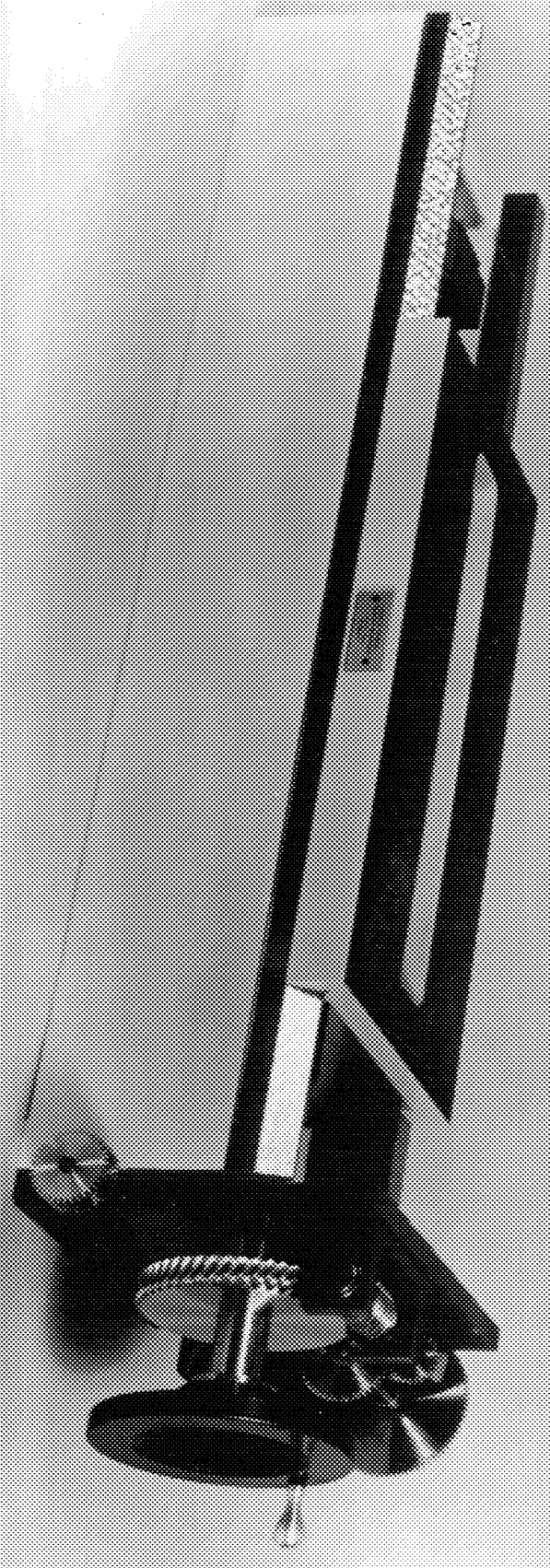
III MATERIAL AND MECHANICAL REQUIREMENTS

3.1 The design and fabrication of all optical and mechanical elements shall be of highest quality workmanship and consistent with the most recent optical and related principles available and shall incorporate such characteristics and quality as required for lens testing bench tests of high accuracy and high precision of measurement.





890 LENS BENCH



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Comparator - Type 841 DRIVE
Microscope -
Projector -
Motor Drive -
Circle -
X Travel - 255 mm
Y Travel -
Auto Readout -

WORM TO WORM WHEEL RATIOS AVAILABLE ARE 12.5:1, 25:1, 50:1 OTHERS QUOTED ON REQUEST.

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